EVALUATION OF THE WAVE ABSORBER AT PENTWATER, MICHIGAN

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This discussion compares incident and transferred energy for gages located within the Pentwater, Michigan boat channel. Comparisons are made primarily by examining the differences in the incident and transferred siginificant wave height, (H_{m0}). Other comparisons use spectral results. Spectral analysis allows the energy of the total wave record to be broken down into discrete frequency bands. Energy inside and outside the wave absorber may then be compared and a transfer factor for each discrete frequency can be determined.

Incident, (lakeside of absorber) and transferred (harborside of absorber) wave data were collected within the Pentwater, Michigan boat channel. Non-directional, internally recording gages, each mounted about 6 inches off the bottom were deployed as indicated in figure 1. The incident gage is MI002 and is indentified as Northwest Channel. This gage was deployed in 11 feet of water and was located 121 feet west of west edge of north wave absorber. The harborside gage is MI004 and is designated as Northeast Channel. MI004 was deployed in 8 feet of water, 72 feet east of east edge of north wave absorber. The purpose of this data collection effort was to determine characteristics of the wave absorber located at the western end of the channel. Wave gages were set to collect hourly using subsurface pressure sensors, however, MI004 collected every 26-32 minutes throughout the study. The sample rate for these sensors was 2 H_z and the burst length was 1024 seconds.

An internally recording directional wave gage was deployed in the open lake at 43 deg 47.101 N 86 deg 27.203 W in 10 meters of water. No data was received from this gage.

Additional directional wave data was available from NDBC buoy 45007 located at 42.67 N, 87.02 W. This gage has a nominal depth of 164 meters and has a burst length of 20 minutes with a burst interval of 1 hour. A comparison of wave heights between offshore NDBC buoy (45007) and the incident channel gage (MI002) is depicted in figures 7 and 8.

1 Analysis

The wave record analysis utilized the Welch, [1], spectral analysis method with 50% overlapping segments. Since the raw time series were obtained using sub-surface pressure systems, a depth determined high frequency cutoff was applied. The averaged co-and quad-spectra from each analyzed record were used to calculate significant wave height (H_{m0}), peak period (T_p), and energy spectrums.

2 H_{m0} Comparison

One way to evaluate the performance of the wave absorber, is to look for a reduction in overall energy. Figures 2&3, show the incident and transferred wave heights, H_{m0i} and H_{m0t}. A visual comparsion of figure 2 and figure 3 show, for high energy events, the transferred energy is less than the incident energy.

To provide a more direct comparison of incident and transferred energy, a transfer coefficient (*xfer*) can be calculated by dividing the H_{m0t} by the corresponding incident H_{m0i}, eqn.1.

$$xfer = \frac{H_{m0t}}{H_{m0i}} \tag{1}$$

Figures 2&3, second plots, are *xfer* values for the months of April and May 2003. The H_{m0t} values were interpolated so that time could be synchronized. The transferred rate varies from 0.40 to 0.80 for most wave records, however, there are a few times with the overall rate above 1.0. For the most part, these high *xfer*s occured during low energy times.

An average energy transfer value was calculated using records from 4/11/03 to 6/1/03 with various ranges of incident wave height. Table, 1, shows how the average percent of incident energy transferred varies with wave height. The average transfer rate using all 1206 available records and was 65.8%. Other averages were calculated using only records with $H_{moi} >$ 0.1, >0.2, and >0.5 meters. The percent of energy transferred increases with H_{mo} once we eliminate the very low energy records, H_{moi} <0.1 meters.

H_{moi}	# Records	Transfer %
All records	1206	65.8%
>0.1 Meters	741	62.1%
>0.2 Meters	466	63.5%
>0.5 Meters	161	67.0%

Table 1: Average % energy transfer

Figures 2&3, also shows plots of incident T_p. On and around 4/25/03, T_p was in fact 128 seconds. These very long period values were deleted from the plots for the sake of clarity. Figure 4 contains 3 examples of pressure timeseries records. The timeseries plots contain 1024 seconds or 17 minutes of pressure data. The wave record is dominated by a single wave of period about 17 minutes. Periodic water level movement is evident in each plot.

3 Spectral Comparison

Figure 5, shows two spectral plots of successive wave records for both the incident and the transferred gages. Note different time intervals. Most energy in both spectrums appears to be less than six seconds, with more energy evident in the incident spectrum. To calculate a transfer rate for the hourly incident waves, the transferred record within 15 minutes of the top of the hour was selected.

A transfer coefficient spectrum, (*xf*) can be calculated by dividing the transferred energy at each frequency by the corresponding incident energy, eqn.2.

$$xf = \frac{E_{tf}}{E_{if}} \tag{2}$$

where E_{tf} is the energy per frequency transferred and E_{if} is the incident energy per frequency.

Figure 6 shows the corresponding hourly *xf* spectrums for figure 5. For most frequencies during this time period, the transferred energy is less than 100%. However, there is substantial increase in energy in the 6.5 second range, about 500%.

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References

[1] P. D. Welch, “The Use of Fast Fourier Transform for the Estimation of Power Spectrum: A Method Based on Time Averaging Over Short, Modified Periodogams,” *IEEE Transactions on Audio and Electroacoustics*, June 1967.

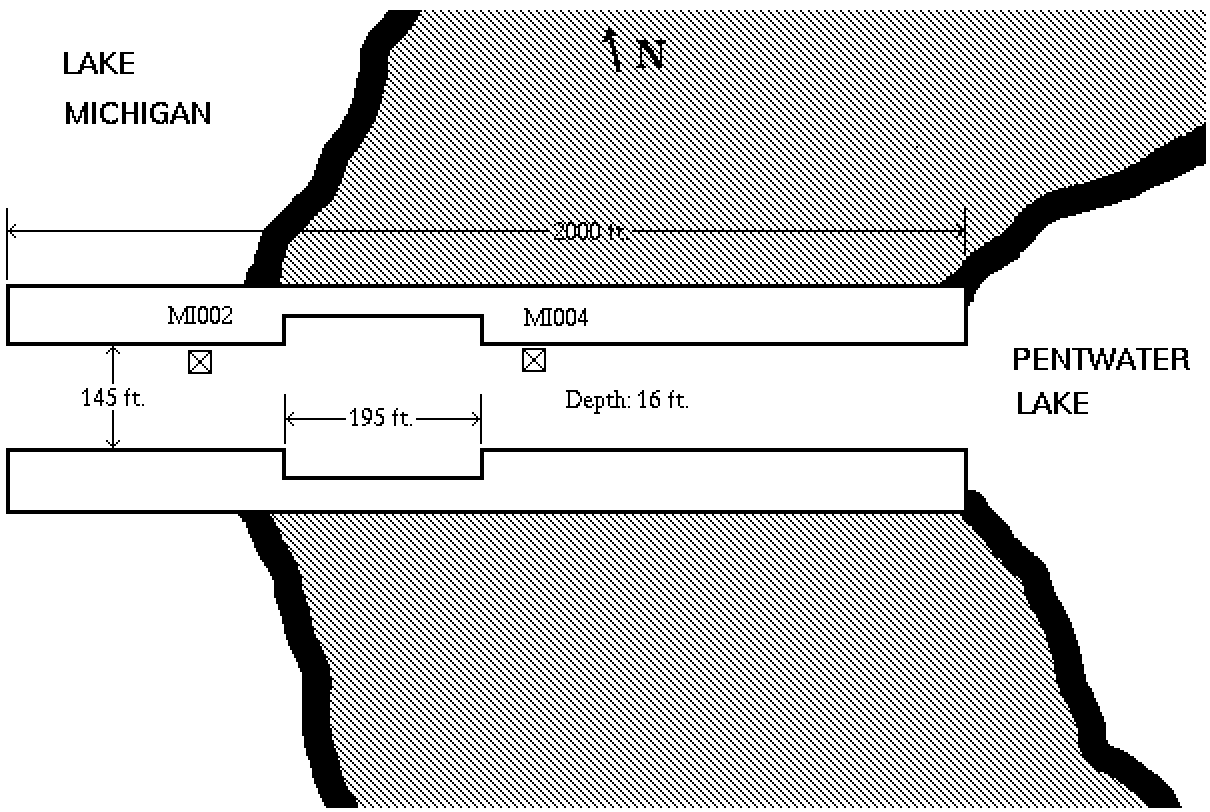


Figure 1: Sketch of Pentwater, Michigan channel with pocket wave absorbers installed. Positions of MI002 and MI004 shown.

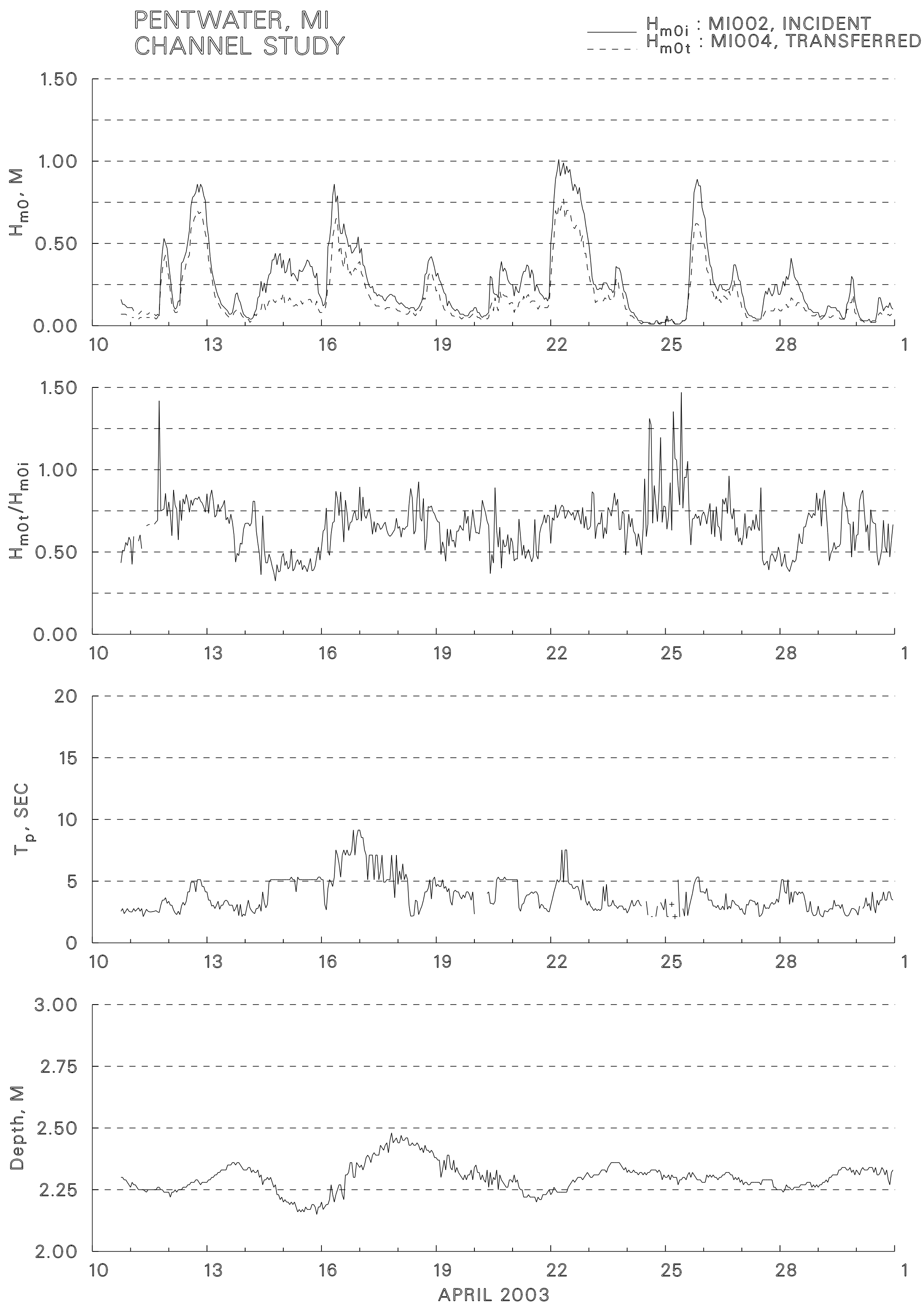


Figure 2: MI002 & MI004 H_{mo} comparison, transfer rates, and MI002 T_p and depth for April 2003.

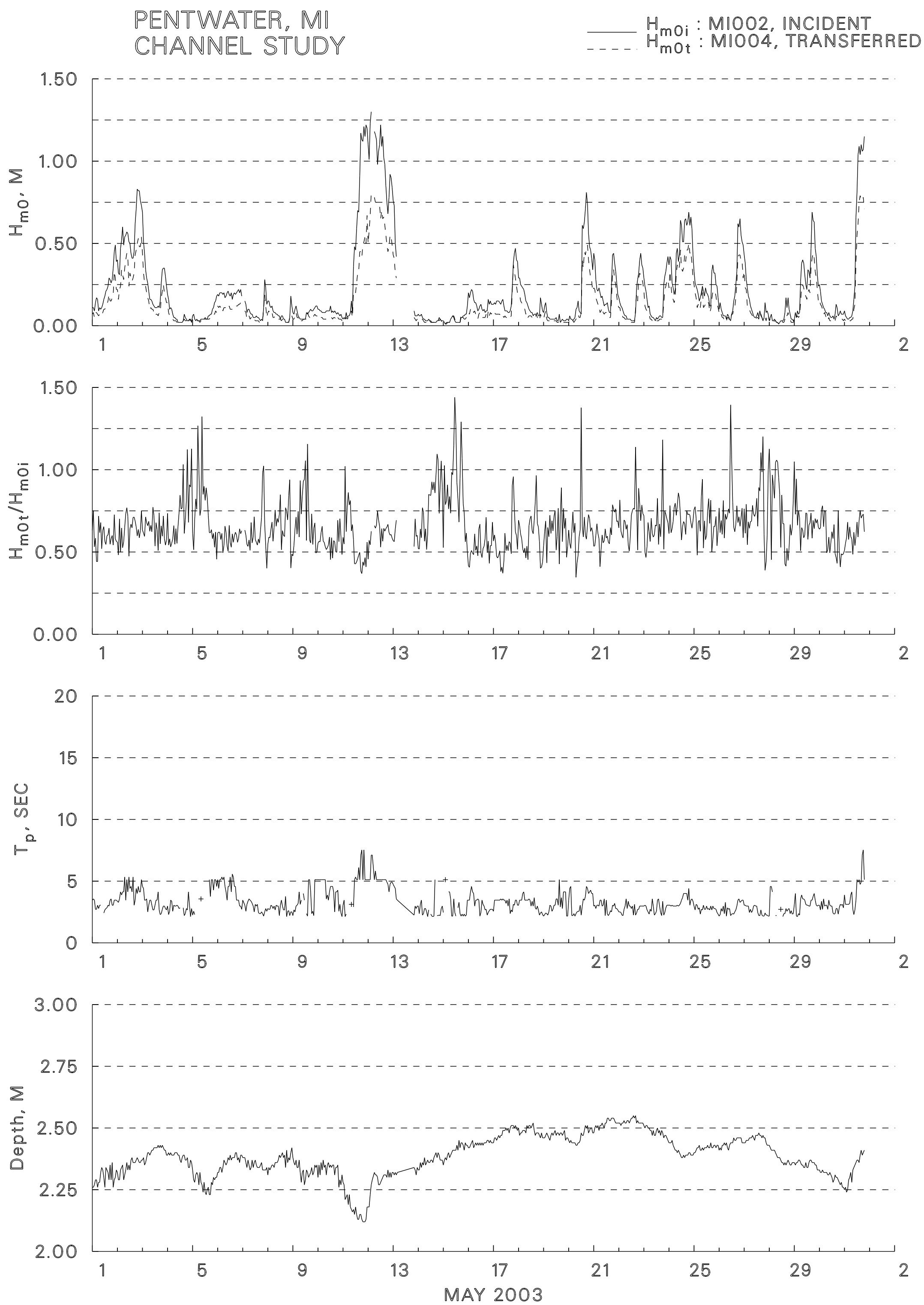


Figure 3: MI002 & MI004 H_{mo} comparison, transfer rates, and MI002 T_p and depth for May 2003.

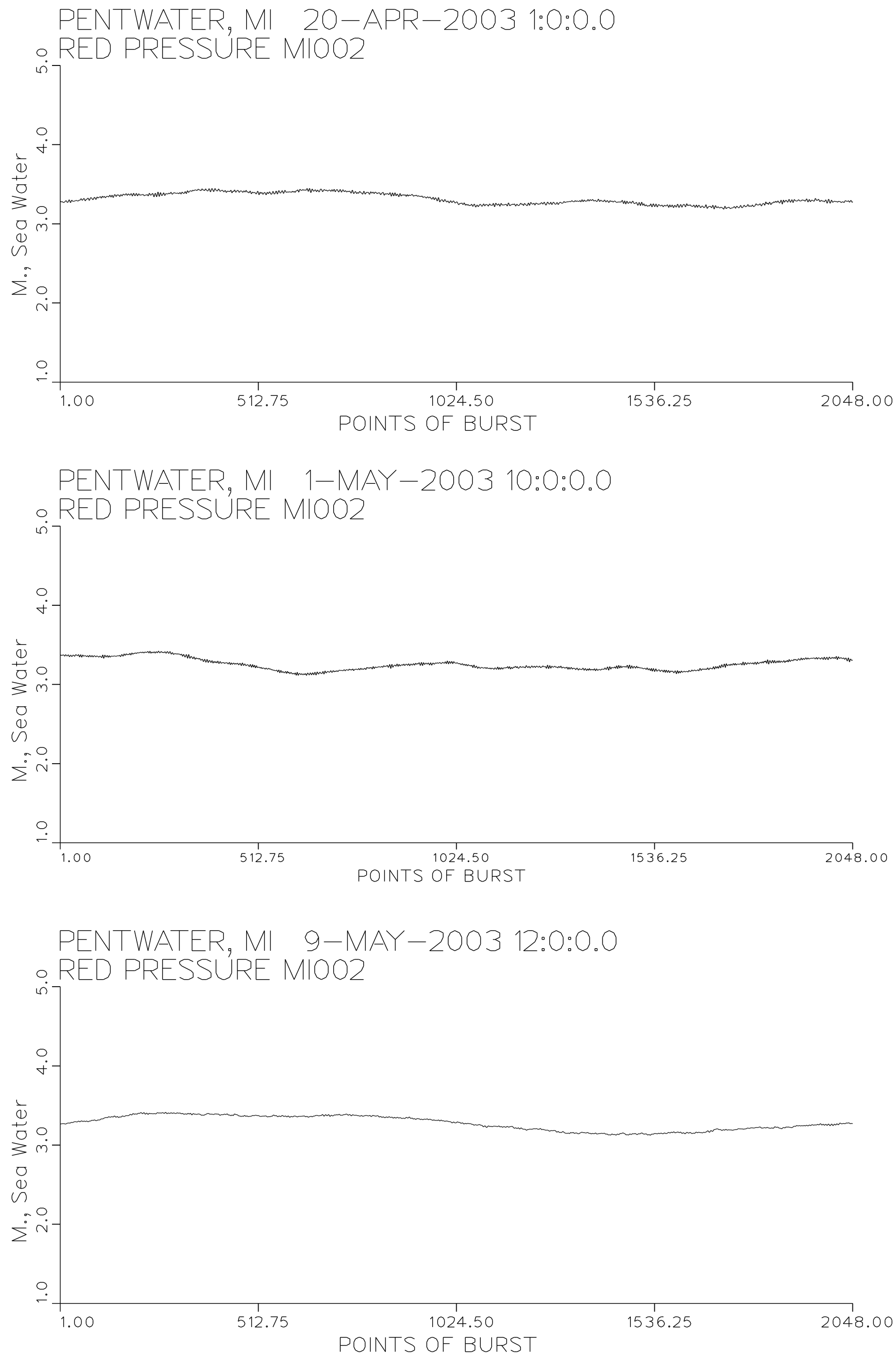
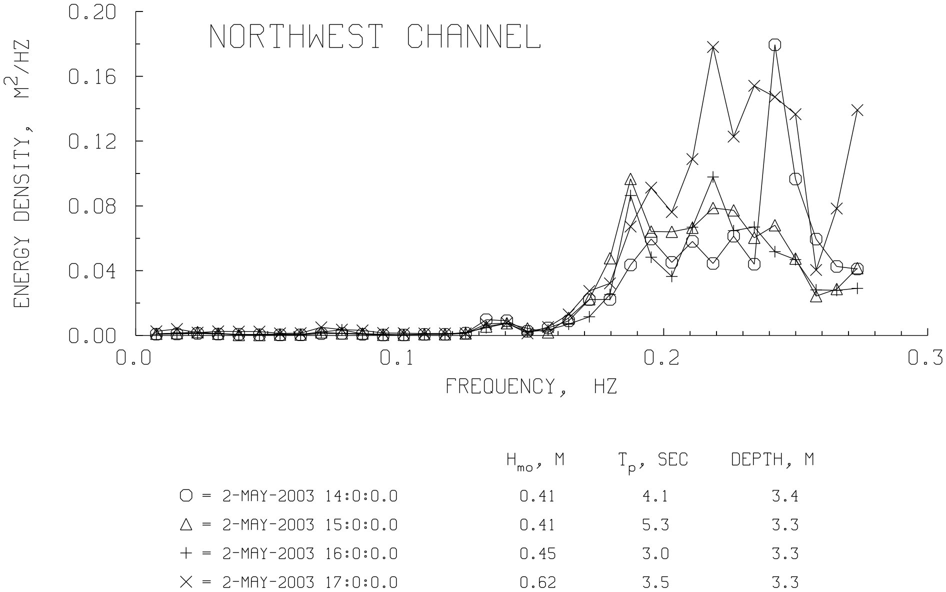


Figure 4: Timeseries plots of water level for selected burst with T_p = 128 seconds. Note the very long period oscillations.



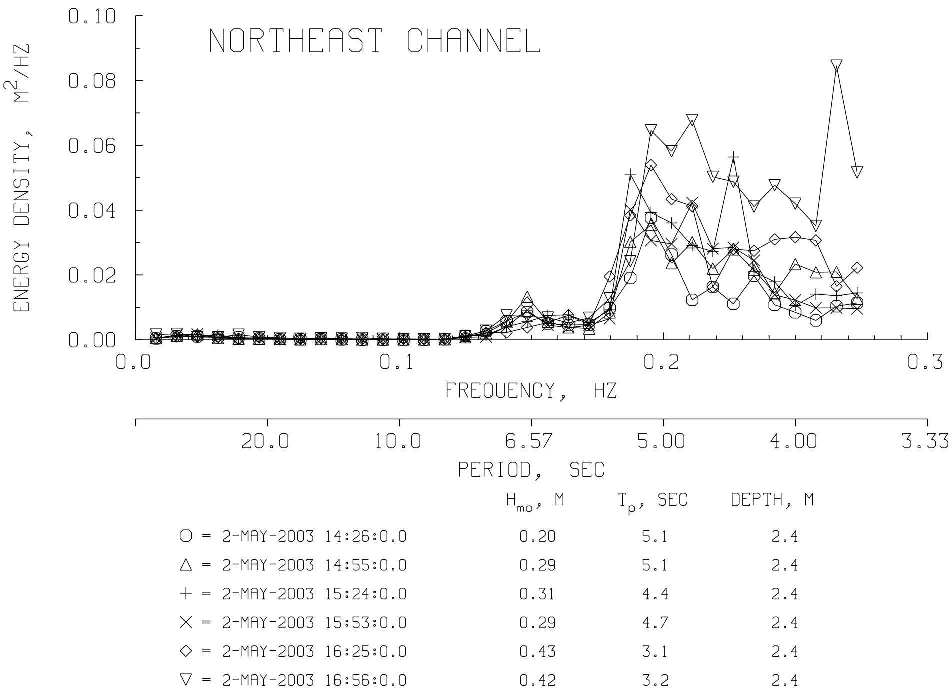


Figure 5: Consecutive spectrums for the incident (MI002, Northwest Channel) and transmitted (MI004, Northeast Channel) gages between 5/2/2003 1400 and 1700 GMT.

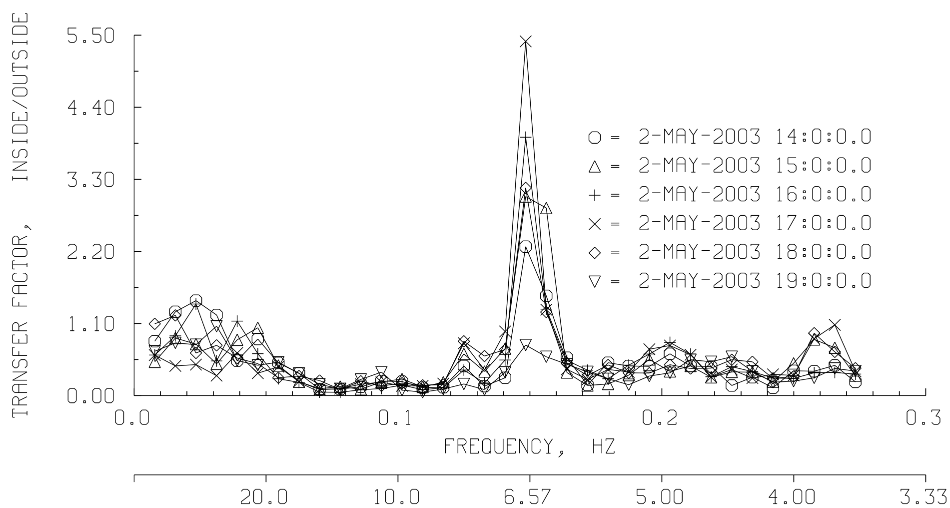


Figure 6: Six consecutive transfer factor spectrums: E_{tf}/E_{if}, beginning 5/2/2003 1400 GMT.

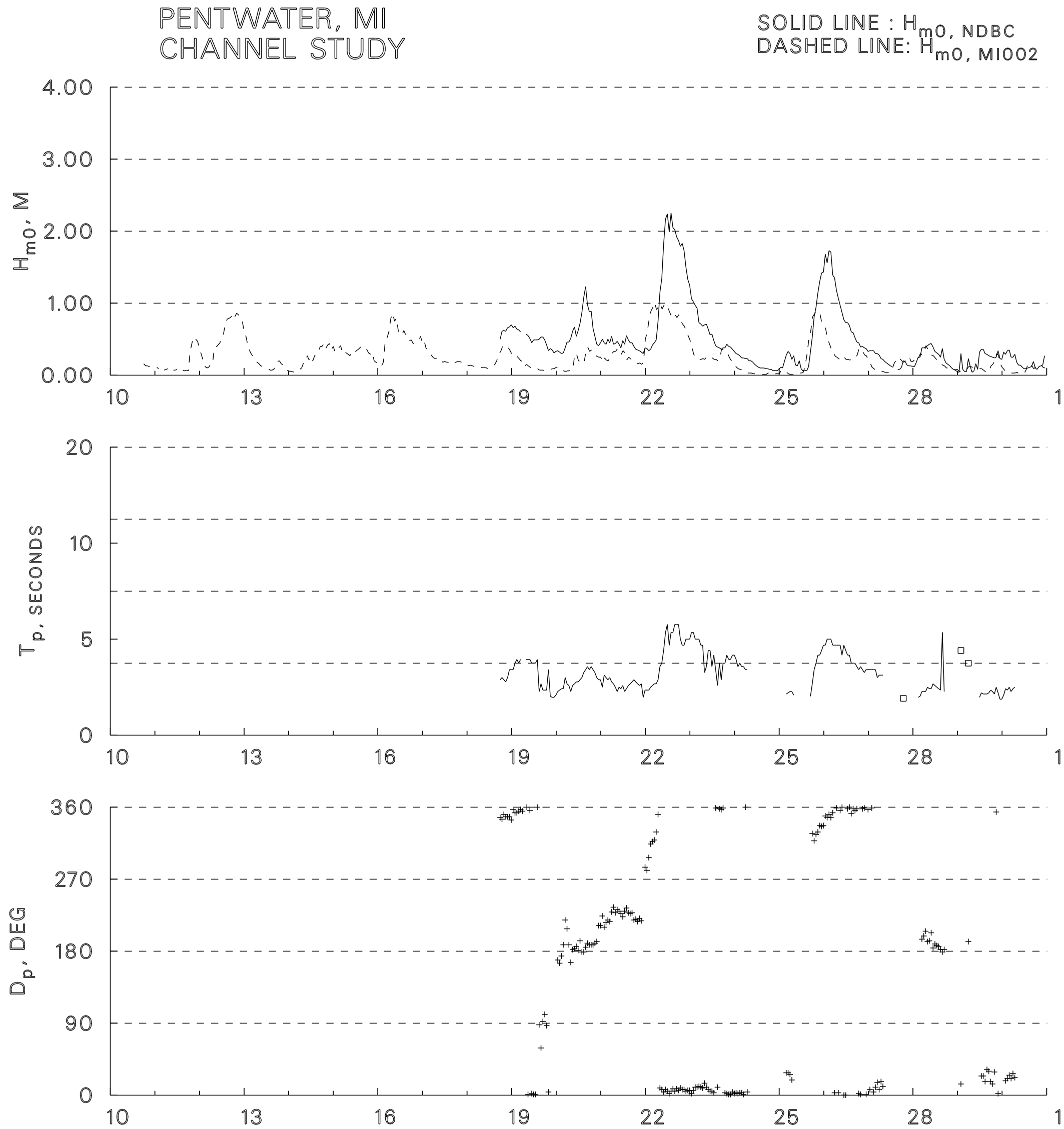


Figure 7: Directional wave statistics for NDBC bouy 45007 for April 2003 with H_{mo} from MI002.

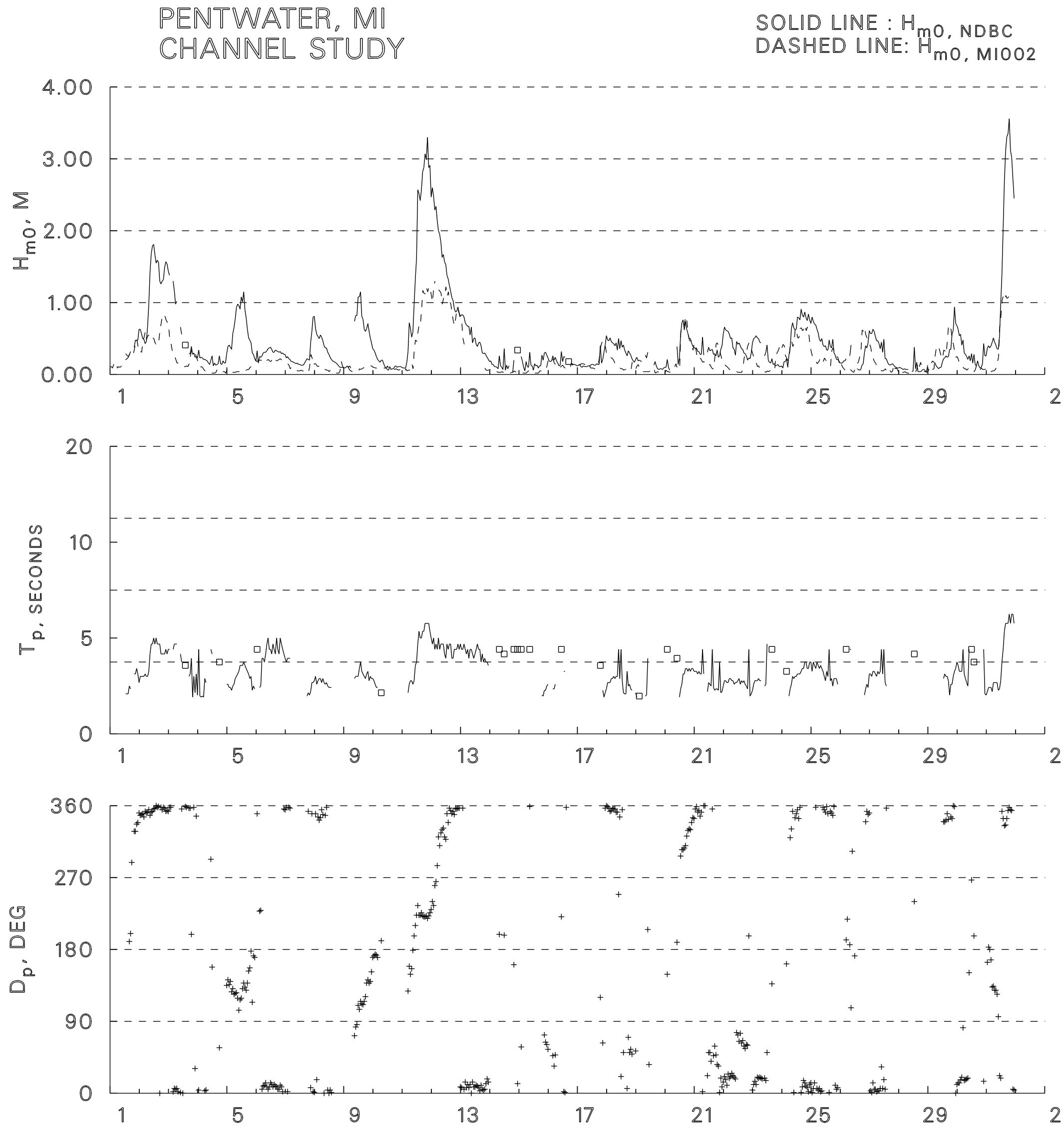


Figure 8: Directional wave statistics for NDBC bouy 45007 for May 2003 with H_{mo} from MI002.